NUCLEAR REACTOR TARGET ASSEMBLIES, NUCLEAR REACTOR CONFIGURATIONS, AND METHODS FOR PRODUCING ISOTOPES, MODIFYING MATERIALS WITHIN TARGET MATERIAL, AND/OR CHARACTERIZING MATERIAL WITHIN A TARGET MATERIAL

STATEMENT AS TO RIGHTS TO INVENTIONS MADE UNDER FEDERALLY-SPONSORED RESEARCH AND DEVELOPMENT

[0001] This invention was made with Government support under Contract No. DE-AC05-76RL01830 awarded by the U.S. Department of Energy. The Government has certain rights in the invention.

TECHNICAL FIELD

[0002] The present disclosure relates to nuclear reactors and target assemblies as well as methods for modifying material within those target assemblies. In pertinent embodiments, the disclosure relates to nuclear reactor target assemblies, nuclear reactor configurations, and methods for producing isotopes, modifying materials within target material, and/or characterizing material within a target material.

BACKGROUND

[0003] At the time of the filing of this application for patent, there is a significant unmet need for some isotopes. One such isotope is molybdenum-99 (^{99}Mo). Radioisotopes have a significant utility for a wide range of medical applications (see, e.g., U.S. Pat. No. 8,126,104) and commercial quantities of radioisotopes such as molybdenum-99 have been produced in nuclear reactors over the years through the uranium fission process (see, e.g., U.S. Pat. No. 3,799,883).

SUMMARY OF THE DISCLOSURE

[0004] It is at least one objective of the present disclosure to provide a radioisotope production target assembly and methods for its use which can overcome one or more of the disadvantages of using a uranium material target. At least one advantage of embodiments of the present disclosure is the substantial amount of isotope that can be produced. Embodiments of the disclosure can eliminate significant amounts of unwanted fission products from the product radioisotope and what may accompany same as a large array of concomitant undesirable infrastructure, health, security, and waste issues and/or associated costs required for this separation. Another advantage of embodiments of the disclosure is the substantial amount of isotope such as ^{99}Mo that can be produced.

[0005] Target assemblies are provided that can include a uranium-comprising annulus, with the annulus defining an outer diameter and an inner diameter, and the inner diameter defining a volume within the annulus. The assemblies can include target material within the volume of the annulus, with the target material consisting essentially of non-uranium material.

[0006] Reactors are disclosed that can include one or more discrete zones configured to receive target material. At least one uranium-comprising annulus can be individually within one or more of the zones. The annulus can define an outer diameter and an inner diameter, the inner diameter defining a volume within the annulus, the volume configured to receive the target material within an entirety of the volume in at least one cross section.

[0007] Methods for producing isotopes within target material are also disclosed, with the methods including providing neutrons to target material within a uranium-comprising annulus; and the target material consisting essentially of non-uranium material. By using the annulus of the target assembly described herein, isotopes can be prepared at a desired activity level using a lower neutron flux than would be needed for the same target material without the uranium-comprising annulus.

[0008] Methods for modifying materials within target material are disclosed as well. The methods can include providing neutrons to target material within a uranium-comprising annulus, with the target material consisting essentially of non-uranium material.

[0009] Methods for characterizing material within a target material are further provided, with the methods including providing filtered neutrons to the target material within a uranium-comprising annulus to activate the material for neutron activation analysis. The methods can utilize target material consisting essentially of non-uranium material.

[0010] Methods for producing isotopes within a target material are also disclosed, with the methods including providing a neutron flux within a target assembly housing an annulus encompassing target material. The neutron flux can be lower than that necessary to produce substantial amounts of isotope in another target assembly that does not house an annulus.

DRAWINGS

[0011] Embodiments of the disclosure are described with reference to the following accompanying drawings.

[0012] FIG. **1**A is an exploded view of a target assembly according to an embodiment of the disclosure.

[0013] FIG. **1**B is another view of the target assembly of FIG. **1**A according to an embodiment of the disclosure.

[0014] FIG. **2**A is an exploded view of a target assembly according to an embodiment of the disclosure.

[0015] FIG. **2**B is another view of the target assembly of FIG. **2**A according to an embodiment of the disclosure.

[0016] FIG. **3**A is an exploded view of a target assembly according to an embodiment of the disclosure.

[0017] FIG. **3**B is another view of the target assembly of FIG. **3**B according to an embodiment of the disclosure.

[0018] FIG. **4** is a view of a cross section of a target assembly according to an embodiment of the disclosure.

[0019] FIG. **4**A is a view of another cross section of the target assembly of FIG. **4** according an embodiment of the disclosure.

[0020] FIG. **5** is a view of a cross section of a target assembly according to an embodiment of the disclosure.

[0021] FIG. **5**A is a view of another cross section of the target assembly of FIG. **5** according an embodiment of the disclosure.

[0022] FIG. **6** is an example transfer cask according to an embodiment of the disclosure.

[0023] FIG. **7** is a schematic diagram illustrating an example of a target assembly transfer method according to an embodiment of the disclosure.

[0024] FIG. **8** is a view of a cross section of a target assembly according to an embodiment of the disclosure.